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THESIS

**THE COST AND BENEFITS
OF REDUCED MANNING
FOR U.S. NAVAL COMBATANTS**

by

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March, 1997

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The increasing cost of manpower in the United States Navy has generated a new initiative identified as Smart Ship. Smart Ship, or the uses of technology for manpower reduction, challenges the culture, tradition and policies of the Navy. The life cycle cost for surface combatants can be reduced following the guidelines of Smart Ship. However, limited analysis has been conducted into the material readiness cost associated with reduced manning. It was the goal of this thesis to concentrate on the cost and benefits of Smart Ship. A maximum savings of 0.54 percent of the total budget for the Department of the Navy is possible, using FY 1996 dollars. Through analysis conducted in the study, the current objective of reducing manpower costs has been determined to be risky and imprudent. Nevertheless, the United States Navy should pursue Smart Ship to enhance combat effectiveness and quality of life, thereby increasing fleet readiness, morale, productivity and retention. These factors will far outweigh any dollar savings from Smart Ship.

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THE COST AND BENEFITS OF REDUCED MANNING FOR U.S. NAVAL COMBATANTS

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ABSTRACT

The increasing cost of manpower in the United States Navy has generated a new initiative identified as Smart Ship. Smart Ship, or the uses of technology for manpower reduction, challenges the culture, tradition and policies of the Navy. The life cycle cost for surface combatants can be reduced following the guidelines of Smart Ship. However, limited analysis has been conducted into the material readiness cost associated with reduced manning. It was the goal of this thesis to concentrate on the cost and benefits of Smart Ship. A maximum savings of 0.54 percent of the total budget for the Department of the Navy is possible, using FY 1996 dollars. Through analysis conducted in the study, the current initiative of reducing manpower costs has been determined to be risky and imprudent. Nevertheless, the United States Navy should pursue Smart Ship to enhance combat effectiveness and quality of life, thereby increasing fleet readiness, morale, productivity and retention. These factors will far outweigh any dollar savings from Smart Ship.

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I. INTRODUCTION

A. PROBLEM

Admiral Bradley Fiske wrote, *"The question of how great a navy any country needs depends, not on the size, but on the policies of that country, and on the navies of the country's that may oppose those policies."* [Ref. 1:p. 114]. Today's shrinking defense budget dictates a policy of reduced operating cost while maintaining mission readiness.

The Department of the Navy (DoN) budget for FY 97 is $75.645 billion, a decrease of 4.6 percent from FY 96, (see Table 1, Appendix A and B). This includes a $730 million decrease in the DoN Military Personnel budget for active Naval personnel, (MPN). However, it has been the single largest appropriation to increase in size as a percentage of the total budget. The military personnel budget for active Naval personnel is now 22.4 percent of the total DoN Budget for FY 97. This represents a 0.9 percent

Table 1. Budget Summary by Appropriation for Military Personnel, Navy, and Operation and Maintenance, Navy for FY95-FY97.

Appropriation	FY95	FY96	FY97
Military Personnel, Navy	17,751.8	17,021.5	16,943.0
Operation and Maintenance, Navy	22,094.6	21,359.0	20,196.2
TOTAL BUDGET	80,417.7	79,252.3	75,645.0

Source: Derived from data provided by "Highlights of the Department of the Navy FY 1997 budget"
Note: Figures are in millions of dollars.

increase from FY 96, and a 5.7 increase from FY 85's active Naval personnel budget, the peak of American military power during the Cold War, [Ref. 2:p. 1]. As the DoN budget continues to shrink, the manpower cost will most likely continue to grow as a percentage of the total budget and overwhelm other appropriations, see Figure 1.

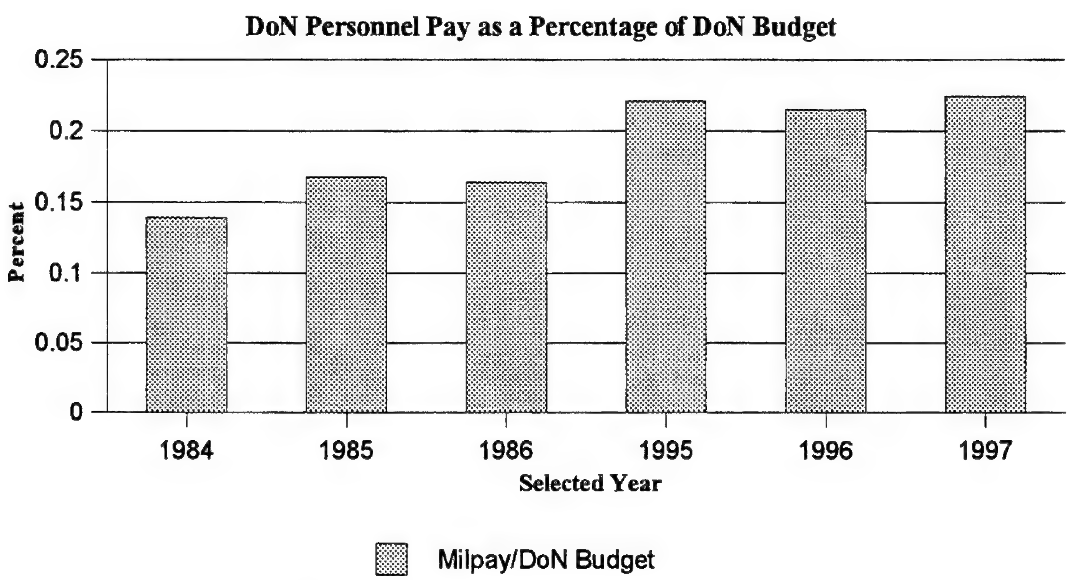

Figure 1. Active Naval personnel pay as a percent of total Department of the Navy budget

Many organizations, including the Department of Defense (DoD), over optimistically expected the draw-down to be over after the objectives of the bottom up review (BUR) 1993, were met. BUR called for 346 active ships and some 406,000 personnel for the United States Navy by FY 99. During FY 97, DoN will obtain these numbers. Meanwhile, the momentum of defense cuts have been so powerful it is predicted by FY 99 there will only be 290 ships and fewer than 400,000 Navy personnel [Ref. 2:p. 2]. To maintain 346 ships, a shipbuilding program of 10 ships per year must be in place. Currently a program only exist for 6.4 ships per year, [Ref. 3:p. 6].

The drawdown is obviously not over. The current administration along with Congress believe the Department of the Navy can operate with fewer ships and fewer people. An assumption must be in place by not only the Government, but by the American people; they believe the Navy can still maintain the current workload and deployment schedule of FY 89, Yet in FY 89 Naval forces were 40 percent larger.

To reduce cost, the United States Navy must examine all variable and fixed costs associated with the budget. The single largest appropriation for FY 97 is 26.7 percent of the budget, which is operation and maintenance (O&M). This represents a decrease of 0.7 percent from FY 95. A quick study revealed there are only 159 steaming days funded out of 365 for a ship on deployment [Ref. 2:p. 2]. Realizing a deployment is 180 days, an average ship is in the red 21 days, excluding workups and exercises. Since the Navy is responsible for safeguarding America's interest overseas on a moment's notice, cutting this appropriation any further seems imprudent.

The next largest appropriation, 23.4 percent of the DoN budget, is the military personnel active Navy budget, (MPN). While leaders of the Navy and Armed Forces agree that skilled manpower is the greatest asset in the Department of Defense, some also believe it can be cut without reducing effectiveness or mission readiness. The Bottom Up Review, (BUR) of 1993 states DoD must adequately fund the O&M account to maintain readiness, which in turn will keep forces well-trained and equipped. However, O&M has already been shown not to be adequately funded under the current administration. The BUR continues by stating a "key element of maintaining forces ready to fight is to ***maintain the quality of our people***. . .". This is to be achieved, first, by keeping personnel highly motivated by treating them fairly and maintaining their quality of life, and second by only recruiting the most talented young men and women, while expanding career opportunities for all service members, [Ref. 4:p. 12].

To maintain a highly motivated force by increasing the quality of life requires decreasing work hours, improving personnel benefits and providing stability for family members. Ironically, DoN proposes to cut manpower on operational combatants, which would place more work on individual sailors. However, through new uses of technology, the Smart Ship initiative is indented to reduce workloads and increase productivity. In this way the crew would be reduced to where crew members would have the same workload as before the introduction of technological manpower savers.

It has been implied that Smart Ship will result in billions of dollars saved over the life cycle of each ship, [Ref. 5]. However, if all the incentives were in-place, including the service members who were removed from ship being eliminated from active service, and

assuming no additional maintenance costs are required due to the technological add-on's, then only a maximum savings of 0.54 percent of the annual DoN budget would be saved in FY96 dollars. This assumes that 119 combatants with an average manning of 401 personnel (376 Enlisted, 25 Officer) could reduce their crew by 25%. The analysis also assumes the 1996 mean annual cost of $75,726 for Officers, and $33,623 for Enlisted, [Ref. 6:p. 10], for details see Appendix A.

The program will indeed save billions over the long term, but this is only a small portion of the whole cost of the Navy. Moreover, it is still uncertain how much this will cost in terms of readiness, training and maintenance. Smart Ship cannot increase the quality of life for the crew if crew reductions only occur in proportion to workloads saved by technology. At best, the accomplishment of Smart Ship will keep the quality of life and moral constant. Therefore, morale will not increase, retention will not increase and mission readiness will most likely decay overtime as equipment ages and material condition worsens.

Following the guidelines of BUR 1993, DoN should carry out Smart Ship not as a manpower savings method, but as a combat effectiveness and quality of life improvement measure, which would indirectly increase morale, productivity, retention and readiness. Intuitively, if this project was used as a quality of life improvement measure, then DoN could save an equal amount of budgetary dollars in training, recruitment and material condition while simultaneously increasing readiness.

B. BACKGROUND

Before the 1970's the cost of manpower had been a comparatively small part of the Navy's annual budget. Then with the advent of the all volunteer force, (AVF), in 1973, military pay began to rise in an attempt to recruit young Americans with pay equivalent to the civilian sector. There were no alternatives; pay had to increase to meet the demand of the force structure required to operate the Department of Defense. However, even with the increased pay, recruitment continued to be a problem. Many operational units experienced shortfalls in the mid-level petty officer ranks. These ranks were the ones which maintained the knowledge base for maintenance and operation throughout the fleet. By 1980, there was a shortage of some 23,300 Petty Officers, and retention was only 50.5 percent for second termers, [Ref. 7:p. 152]. It was not until President Reagan gained office in 1981 that the military began a slow rebound.

Under President Reagan and the Secretary of the Navy, John Lehman, the U. S. Navy began a plan for a 600 ship Navy, [Ref. 8:p. iii]. It was well known that the labor supply market for 18-24 year olds would decrease approximately 2.2 million by the mid 1980's from the late 1970's, [Ref. 9:p. 9]. Plans were analyzed with the same idea. The force needed to expand to meet the operational requirements for a 600 ship Navy. Since there would be fewer young Americans from which to recruit, there needed to be more efficient ways to use people. Specifically, the Navy had to man more ships, while increasing operational readiness and constraining the manpower budget.

During the Carter administration, FY 79, there were 458 ships. The total number of personnel in the United States Navy was 523,937, [Ref. 10:p. 7]. Today, there are 362

ships and 419,599 active forces in the United States Navy, [Ref. 3:p. 32]. The ratio between total personnel and active ships is 20 percent higher today than at the beginning of the AVF in 1973, see Figure 2. Technological advances would suggest that the opposite effect should have occurred with a decreasing ratio of manpower per ship over the past 20 years. Although this is aggregate data, it provides insight on how technology as a whole has not been used effectively in the United States Navy to reduce manpower requirements.

The United States Navy is primarily a sea-going organization. Specifically, the product of the Navy is to provide fully combat ready ships forward deployed. All personnel in the United States Navy have the same objective; to support the fleet

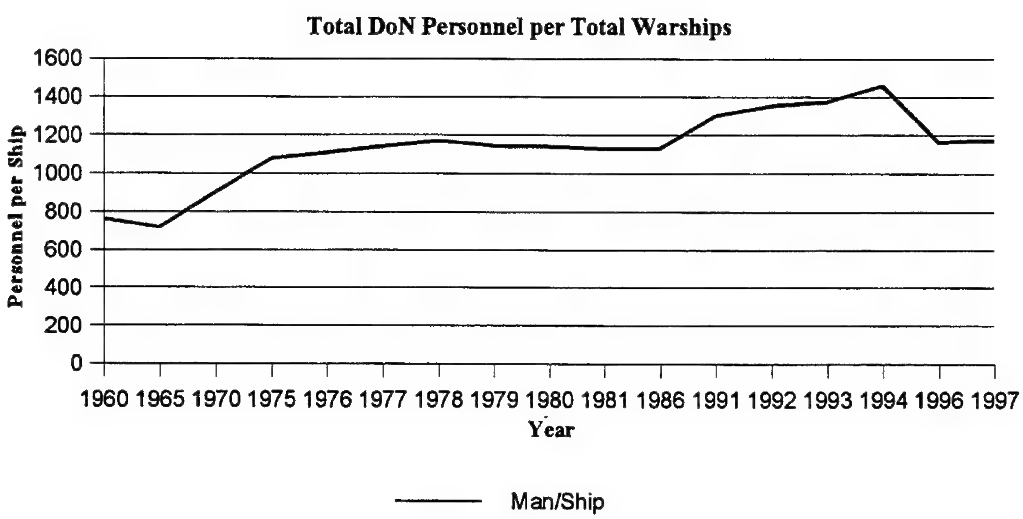

Figure 2. Department of the Navy Personnel ratio to total Warships.

ensuring the quality of the product. The 20 percent increase in the ratio of total manpower per total ships suggests that since the American government requires a similar OPTEMPO of that in 1989 with fewer ships today, more personnel are required to ensure success and safety in those operations.

Over the past 30 years, seven administrations have held office with different objectives and plans for the United States Navy. This has influenced the number of U. S. Navy ships from around 1000 to the projected 346 by FY '97, see Figure 3, [Ref. 2:p. 6].

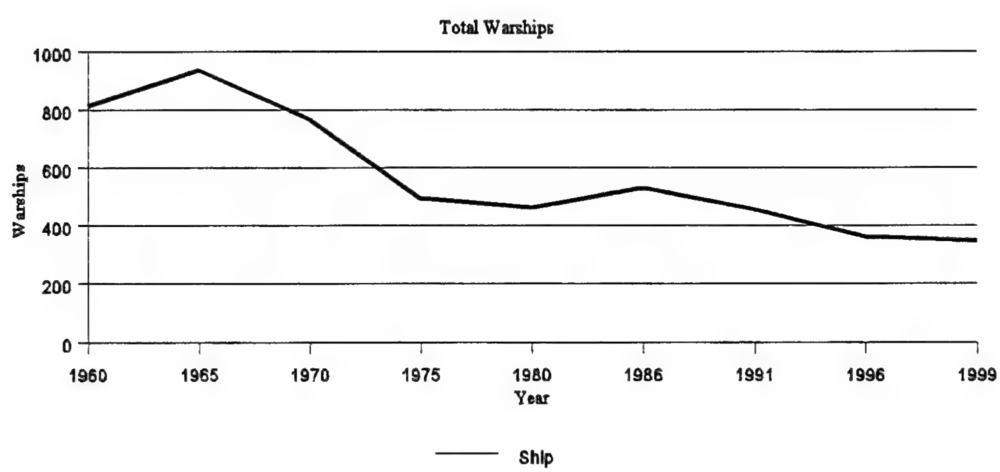

Figure 3. Total Active Warships

In the 1950's the USS Forest Sherman Class, DD 931, required a manning level of 337 men. Displacing 4200 tons, this destroyer conducted ASUW, AAW and ASW. It used three main guns, four AAW guns, and two missile launchers for Hedge hogs (ASROC) for ASW or Tarter missiles for AAW, (after conversion), [Ref. 11]. Today the Arleigh Burke class guided missile destroyer displaces some 8000 tons with an average manning of 338 men. DDG 51 is armed with 90 vertical launch cells containing AAW missiles (SM2), ASW weapons (VLA) and strategic strike missiles (Tomahawk-TLAM). DDG 51 is also equipped with one 5-inch gun (5/54 MK 45-mod 1), a close in weapon system and Harpoon anti-ship missiles, [Ref. 11].

The differentials between these platforms cannot successfully explain the differences in ship capabilities. There is no doubt, the DDG 51 class is more technologically advanced than the DD 931 class. However, examining the two era's, the capabilities of these platforms against the capabilities of their foes at the time of their commissioning, DDG 51 and DD 931 are somewhat equal platforms. It is the author's assertion that DD 931 in its time era of warfare is equal to DDG 51 in its time era of warfare. Therefore, uncertainty arises as to why the difference in displacement.

One of the answers to the differences in displacement is probably because of improved habitability and quality of life for sailors, [Ref. 7:p. 130]. Another answer provided by Vice Admiral Walters, DCNO for surface warfare during the FY 84 congressional budget hearings was "Extra space is built into ships to provide for mid-life upgrades" [Ref. 7:p. 135].

During other congressional hearings on the increased size of Navy ships, analysis

was pointed out that the US Navy had to operate in high and rough seas, forward deployed, for substantial periods. It was also determined that complex, shipboard systems accounted for most of the shipboard life cycle cost, not hull size. The reasoning for this was based on how fast these complex systems became obsolete. Hull life, however, was still at 30 plus years. Therefore, hull size was pointed out to be critical in the flexibility of updating systems with more sophisticated and technologically advanced weapon systems [Ref. 7:pp. 134-135].

Admiral Boorda realized manpower was not being used effectively throughout the fleet. "For my entire thirty-nine year career, we always talked about buying ships and manning them with people . . . I think we need to think about things differently now. We need to figure out how to have the fewest number of people possible, and then build [ships] to make them as effective as they need to be.", [Ref. 12:p. 21]. After the completion of a study by the Naval Research Advisory Committee, Admiral Boorda requested a test platform to examine and validate recommendations for manpower reductions on a surface combatant [Ref. 12:p. 83].

The Smart Ship project was initiated, and hundreds of technological ideas were forwarded to Washington to reduce manpower. Many focused on the procedures of the merchant fleet. However, the most crucial and realistic ones were occurring under the direction of the Commanding Officer of the USS Yorktown, (CG 48). It was in the interest of the Commanding Officer of the USS Yorktown to ensure he could still fight the ship, while not increasing the already extensive workload for his crew.

C. OBJECTIVES

The purpose of this study is to analyze the cost and benefits of Smart Ship, and reduced manning through the uses of technology, as it pertains to mission readiness. The primary question the study will address is:

Is Smart Ship cost effective? More specifically:

1. Will the reduction of crew members as a result of Smart ship worsen material readiness, decrease crew moral and overall affect the readiness of the future fleet?

2. Does the current Smart Ship objective indicate the way for the Navy to operate in the 21st century?

3. Has technology reduced the manpower requirements for U.S. Naval Combatants over the past century?

4. If technology has not significantly reduced manpower, than what is the major factor in the reduction of manpower for U.S. Naval Combatants?

5. Can the United States Navy depend on technology to reduce manpower in the future?

6. In what ways has the Navy benefited from technology?

7. Is the fleet of today in its era of technology equal to the fleet in the mid 1950's in its era of technology, holding all else constant? (i.e. Does the Navy have a more strategic offensive and defensive capability today than we did 45 years ago?)

8. What alternatives are available for current Naval leaders to reduce Navy manpower?

D. SCOPE AND LIMITATIONS

This study will focus on the Smart Ship project in place on USS Yorktown, (CG 48). It will cover the impact of reduced manning on mission readiness by examining the Smart Ship project, and other major surface combatants over the past 30 years. Analysis on cost savings will be conducted for the project to determine if Smart Ship is the best alternative to pursue. The thesis will also provide recommendations on how to assess the accomplishments of the project after the completion of USS Yorktown's deployment in the spring of 1997. Background studies on Destroyer, Cruiser, and Frigate class ships will provide insights on how the Navy can maintain readiness.

E. ORGANIZATION

This thesis will include five Chapters. Chapter I defines the problem, and provides background information. Chapter II will include various background studies on measuring ship productivity, material readiness and material condition. The Center for Naval Analyses (CNA), has studied manpower and the relationship with ship productivity for more than twenty years. Other information in this chapter will make the reader aware of basic labor economics and the substitution of capital for labor.

Chapter III will present the new theory of Smart Ship. It will contain current objectives, progress and future goals for the program and USS Yorktown. This chapter will also provide information on the capabilities of USS Yorktown and her current and future mission responsibilities.

Chapter IV will discuss analysis on the cost and benefits of Smart Ship. This chapter will provide analysis from previous studies of readiness. Facts of Smart Ship will be based from interviews on board with the Commanding Officer, the crew of the USS Yorktown, the Smart Ship Project, (SSP) office, and from reports in the media and Internet, the Naval Research Advisory Committee and presentations from Captain Barker, USN, SSP team.

Chapter V will contain conclusions on the cost and benefits associated with the current program of Smart Ship, along with options identified by the cost benefit analysis (CBA). Recommendations will include modifications to the current program's objectives and identify some precautions in the assessment of the program. Insight on the manning of future combatants, including the SC 21 and Arsenal ship will be provided. Areas of further study will be provided, and how Smart Ship might play a part for the Navy in the 21st century.

II. LITERATURE REVIEW

A. INTRODUCTION

The United States Navy has been criticized for not using available shipboard technology to reduce manpower on today's combatants. This is primarily due to culture, tradition, and policy. There have been few incentives for the Navy to change. This past century has proven a well prepared Navy and National defense is needed in safe guarding America's interest, both domestic and abroad.

Smart Ship tears down the walls of culture, tradition and policy, [Ref. 5]. It provides the Navy with real time thinking and solutions for manpower reduction on surface combatants. However, limited analysis has been conducted into the material readiness cost associated with reduced manning

Smart Ship provides clear answers for reduction in shipboard operation and control. It uses common sense approaches, along with "off the shelf" technology to reduce manning requirements for watch stations. However, it does not provide for the unscheduled, corrective maintenance and emergent repair that is familiar to any sailor. Therefore, it is uncertain if the reduction of crew members will result in worsened material condition, decreased moral and overall affect the readiness of the fleet.

B. SHIPBOARD READINESS

"Ships are complex, and because many equipment failures are random or from unidentified causes, even identifying average systematic linkages between ship material condition and resources available to the ship has been difficult...", [Ref. 13:p. 1].

Measuring readiness for surface combatants is extremely difficult. There are no quantifiable numbers or scales to evaluate individual units or battlegroups. Instead, readiness is evaluated at certain intervals through different departments over training cycles. Nothing is consistent nor concrete between platforms or inspections. Rather, it is a relative ranking from opinion, experience and minimum requirements. If a ship meets all of the minimum requirements, then it is presumed ready to deploy. As all sailors know, some ships are more ready than others.

Despite many attempts at some stronger indicators over the years, there are no solid measures for readiness. Factors considered often include the number of outstanding casualty reports, (CASREPs [1]), the time required to repair the casualty, the level of readiness on the Status of Resources and Training (SORTs[2]) report, and individual grades on departmental examinations, assessments, and certifications. However, the bottom line for a ship being ready is being on station, on time, performing its mission as designed.

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[1] CASREPs are submitted to area commanders reporting degradations in mission capability. They are organized in categories of CAT 2, CAT 3 and CAT 4. CAT 4 is the most serious degradation to a primary mission area. CAT 2 is a minor degradation to either a primary or secondary mission area which requires only simply parts to fix. Supply information is provided with these reports to provide parts as soon as possible.

[2] SORTs is a message submitted to the Joint Chiefs updating shipboard readiness. Some of the categories are material condition (CASREPs), personnel, fuel and ammo.

Deploying CASREP free is a milestone for every ship to achieve. This is one indicator of a highly maintained ship with the highest levels of material readiness. This is also an indicator of the correct resources and manpower aboard to repair casualties. Three studies at CNA, which examined combatant readiness by analyzing CASREP data demonstrate complex and technological equipment requires highly skilled technicians to maintain it. Specifically, these studies provide statistical evidence that highly skilled labor used in challenging jobs result is less CASREPs per ship.

The first two studies, both by Horowitz (1977) broke out equipment systems into subsystems listed in Table 2. By breaking up systems to identify ratings responsible for

Table 2. Horowitz and Sherman's subsystems and ratings responsible for maintenance and upkeep.

Subsystem	Associated Rating
Boilers	Boiler Technician (BT)
Engines	Machinist's Mate (MM)
Gun Systems	Fire Control Technician (FT) Gunner's Mate (GM)
Missile Systems	Fire Control Technician (FT) Gunner's Mate (GM)
ASW Systems	Gunner's Mate (GM) Sonar Technician (ST) Torpedoman's Mate (TM)
Sonars	Sonar Technician (ST)

Source: Horowitz, Stanley A. and Sherman, Allan, Crew Characteristics and Ship Condition, p. 2, Center for Naval Analyses, Alexandria, Virginia, March 1977.
Note: FT has become FC, GM has divided into GMG, and GMM and ST has become STG.

maintenance and repair, Horowitz believed he could determine which rates were more productive. Therefore, if a subsystem experienced less CASREP downtime, the individuals responsible for the equipment were presumed higher skilled and more productive, relative to their counterparts. While this may be a less than comprehensive approach, it is interesting and provides insight. It allowed Horowitz to identify key personal attributes, including being single and a high school diploma graduate, (HSDG) as positively correlated to increased shipboard readiness.

The most statistically significant factors associated with readiness were high skilled technicians. High skilled technicians were categorized as HSDG. If a HSDG was placed in a technical rating, CASREP downtime decreased, implying increased productivity. However, if these individuals received non-technical assignments, their subsystems had higher CASREP downtime, implying decreased productivity,

[Ref. 14:p. 3].

Quester, (1989) demonstrated that higher skilled sailors, along with lower rates in crew turnover and increased steaming hours underway resulted in less CASREPs per ship. Quester studied three different ship classes. The Knox class frigate, the Adams class guided missile destroyer and the Spruance class destroyer. She showed that quality personnel, decreased crew turnover and OPTEMPO were statistically significant in increasing material condition and shipboard readiness.

1. Personnel

Higher skilled entrants have longed been desired by the military since the AVF, in 1973. To attract these individuals requires competitive wages and opportunity for them to excel, [Ref. 15:p. 1]. To keep such individuals requires more. People must feel challenged and wanted. Trust and confidence also play a part in wanting to stay at an organization. However, one of the most important feelings that affects an individual's commitment is stability. Stability is not only in having a job and a pay check next month, but stability is being in the same city for more than 24 months and time spent with ones family.

The military has always been a hard way of life for a service member with a family. The constant deployments, training, and uncertainty of world events creates feelings of discontent towards the military, and a wanting to get out. In years past, the factors of retirement and benefits earned from a 20 year commitment were more valuable and persuasive than today. Today's sailors are required to deploy more, and do more than those years ago in order to maintain the readiness of the fleet. Even inport periods, which used to provide families with valuable reunion time, are now burdened with maintenance, repair, preparation, training, inspections and preservation, all in attempt to maintain high standard fleet readiness.

If the Navy wants to keep these valuable, highly skilled workers, then it must make a commitment to them. The Navy needs to increase the quality of life for all of its members. The money saved from retention and training would far outweigh the cost of the improvement.

2. Crew Turnover

Crew turnover has long been a problem in the Navy. To improve readiness, Quester recommends reducing crew turnover in the months before deployment. The problem associated with this is too many sailors want off sea duty for reasons listed in section 1. In addition, some of the current problems experienced today are directly associated with the poor management of personnel in the Navy by BUPERS. For example, all Navy personnel are assigned prospective rotation dates, (PRDs) and an end of active obligated service, (EAOS). The problem does not exist for first termers, because the dates are the same. However, when sailors reenlist, they are assigned a new EAOS. Then, later when they receive orders to a command, for example a ship, they receive a PRD. The PRD is usually 2 years further out than the EAOS. The problem exist when at the EAOS, the sailor has up until the eleventh hour to decide if he or she will reenlist. If the sailor stays, then there is no problem. However, if the sailor decides to get out, the command now is confronted with a gapped billet until filled. The billet is usually filled with a first termer, with less experience and knowledge then the second termer who left. This in turn creates turbulence for all in the work center and division, [Ref. 16:p. 20].

BUPERS may argue that this is unavoidable. They might suggest a command could use better management in determining if someone will reenlist or get out. While in some instances this may be true, it is not guaranteed for all. For a command to guarantee a fill as soon as possible, it would need to adjust the PRD to the EAOS. Then, if the member decided to stay in the Navy, an extension would be required or else the command would lose the member, along with the experience base.

If a command suffers from such a gap, then it will go into a queue of fills depending on urgency. The most urgent billets to fill are those commands in a deploying status. This in turn denies commands the ability to receive crew members early enough to train and acquaint them to the rest of the ship.

Training personnel on combatants requires repetitive instruction and drills to attain proficiency and productivity. Training time is a constraint dictated by maintenance and allowed steaming hours. Steaming hours as mentioned in the introduction have been cut to 159 days for a deploying ship.

Other problems in crew turnover have further increased with Admiral Boorda's new policy for division officers, DIVO. The old policy kept division officers at a command up to 36 months. Then, usually a DIVO did a follow on tour for 18 months on another platform. During the first tour, a DIVO would obtain qualifications and experience as a manager. The DIVO would also gain knowledge of his or her equipment and how to conduct business in the fleet. The policy now in effect limits DIVO time for a command to 24 months. It is the duty of the first command to ensure the DIVO has a qualification pin as a Surface Warfare Officer and limited knowledge to prepare him or her for their next 24 month assignment as a DIVO aboard another, different type of ship. This policy requires a command to train more DIVO's than before, adding to the already full work day and creating more crew turbulence.

Studies prove that a crew that trains together and remains together is far more ready then the high crew turnover commands the Navy policy is creating. If Smart ship is to happen, a major obstacle will be in keeping highly skilled workers aboard longer,

eliminating the high turn over rates. If a ship is to be effective with less crew members, than they must be fully trained before they arrive, stay for longer periods, and detach only when a replacement is competent to perform the task.

3. OPTEMPO

The third significant variable Quester studied which affected readiness was increased steaming hours. It seems common sense for any sailor that the more time spent together training underway would result in higher material readiness. This underway time helps work out any "bugs" in equipment and personnel. It also allows personnel to be away from the influences of home and to keep their mind on the job. The draw back to this is when inport, crew members must be given a routine which allows for stability. Quester discovered that those commands which did not commit to a constant, routine workup prior to deployment, by pushing all underway time into the quarter before, resulted in worsen material readiness.

4. Other Readiness Factors

While each ship class was studied independent of the other three, examining the predicted average percent time free of CAT 3 and CAT 4 CASREPs provides insight that technology may be an equalizing factor for lesser quality sailors. Specifically, Table 3 shows that higher quality sailors increase the percent of CASREP free days. These are the number of days during the month that a combatant is free of CAT 3 and CAT 4 CASREPs. Table 3 shows that for individuals one percentage point below the mean for

Table 3. Predicted Average Percent Time Free of Mission Degrading C3/C4 CASREPs

	Knox class	*Adams* class	*Spruance* class
Predicted for means of all variables	68.5	51.9	70.2
Changes from overall mean prediction when QUAL_MAN is			
One percentage point above mean	70.4	55.2	70.7
One percentage point below mean	66.5	48.6	69.7

Source: Quester, Aline O., Enlisted Crew Quality and Ship Material Readiness, p. 7, April 1989.

the variable QUAL_MAN, Quester's quality variable, decrease the percent of CASREP free days. However, the Spruance class destroyer only decreases .5 percent, while the other two less sophisticated combatant types decrease 4 to 10 percent. Based on that data, technology maybe an equalizing factor for lesser skilled personnel.

Ship age and equipment reliability may also play a factor in these results. This is verified by Horowitz who found that equipment reliability for engineering plants was dependent upon overall age and the reliability for weapon systems was dependent upon the length of the time interval between overall periods, [Ref. 17:p. 13].

Material readiness can be an indicator of qualified, trained personnel onboard to maintain and repair equipment. However, there are other factors which have been mentioned that bias the results. Therefore mission readiness cannot be determined solely by CASREP data.

Another indicator of readiness is how fully trained and proficient a crew is. By examining SORTS data, CNA, (Center for Naval Analyses), determined variables which

increased a combatants ability to deploy fully combat ready. A list of the significant variables are listed in Table 4.

Table 4. Description of variables and data sources used in Quester and Marcus logit model.

Variable	Description	Data source
DEPLOY_C1	Training readiness was C1 when the ship deployed	SORTS data, formerly called UNITREP
MANREQ	Enlisted manning relative to M+1 manning requirements[3]	DMDC UIC tapes and billet file data
PNEW3	Percent of enlisted crew new to the ship in the three months prior to deployment	DMDC UIC manning data
NEW_ENG6	Percent of enlisted crew in engineering ratings new to the ship in the six months before deployment	DMDC UIC manning data
PAC	Value of 1 if ship in Pacific Fleet	Ship Employment History File
YEAR	Year deployed	Ship Employment History File
C3/C4 CASDAYs	Total of C3 or C4 CASREP days in the six months before deployment. For example, two outstanding C3 or C4 CASREPs for an entire 30-day months are defined to be 60 CASDAYs.	CASREP data
MSO	Months since overhaul for ships except FFG-7s. Because FFG-7s do not have overhauls, MSO is defined as months since C5 status.	Ship Employment History File and SORTS data

[3] MANREQ is defined as a measure of the ship's enlisted manning relative to the requirements. However, it is not simply a count of enlisted manning relative to the requirements. It is a function which encompasses the mix of paygrades to include the different levels of productivity in levels of paygrades. The assumption is higher paygrades are more productive.

Table 4. (Continued)

Variable	Description	Data source
SUBSEQUENT_DEPLOY	Control variable with value of 1 for a deployment that is not the first since an overhaul	Constructed from Ship Employment History File
AVG_SHU	Monthly average of steaming hours underway for the six months before deployment	Ship Fuel and Hours data
AVG_SHN	Monthly average of steaming hours not underway in the six months before deployment	Ship Fuel and Hours data
SHU1	Steaming hours underway in the month before deployment	Ship Fuel and Hours data
AVG_UND	Average proportion of days underway in the six months before deployment	Ship Employment History File
UND1	Proportion of days underway in the month before deployment	Ship Employment History File

Source: Quester and Marcus, How OPTEMPO, Crew Turnover, and Material Condition Affect the Training Readiness of Surface Combatants, pp. 4-5., March 1989.

One of the most statistically significant variables for decreasing the probability of deploying C1 in training was PNEW3. This variable, which identifies crew turnover, decreases the probability of deploying C1 when crew turnover occurs in the quarter before deployment. The effect, while not statistically significant, was negative even if crew turnover occurred two to three quarters before a deployment. The variable provides interesting evidence that crews should spend a maximum amount of time together by decreasing the amount of turnover per quarter and extending time onboard. A change in routine would be required if sea duty was expanded. The change would need to include a

decrease in the intense work hours which have been known to wear down sailors and decrease their productivity.

Another significant variable listed in Table 4, related to manpower is MANREQ. A function which accounts for the mix in paygrades to include the productivity levels, (E1-E9), MANREQ assumes the higher the paygrade the higher the productivity. See Appendix D.

The variable MANREQ is the ratio of the sum of the basic pay of enlisted personnel currently on board (COB) divided by the basic pay of personnel required as M+1. MANREQ indicates the higher the ratio, or the closer COB was to M+1, the higher the probability a combatant had of deploying C1, or fully combat ready. The CNA study also found that the more people a command had, the better its chances in deploying fully combat ready. This cast doubt on Smart Ship's efforts toward reduced manning.

Another variable consistent with training is OPTEMPO. CNA showed that increased operating schedules and underway steaming at a steady pace over several quarters before a deployment resulted in a higher probability of deploying C1. However, if a ship attempted to increase OPTEMPO in the last quarter before the deployment as in a "catch up pattern" then the results proved a strong negative effect in the probability of deploying C1, [Ref. 18:p. 16], see Table 5. The study verifies the earlier work of Quester (1989) using CASREP data.

Table 5. Estimated historical effect of changes in independent variables on the likelihood of deploying C1 in training, as discovered by Quester and Marcus

Change in independent variable	Effect on likelihood of deploying C1 in training
Decrease NEW_ENG6 by 2 percentage points	.83 to .86 percentage point increase
Decrease C3/C4 CASDAYs in six months before deployment by 25 CASDAYs	.71 to .83 percentage point increase
OPTEMPO	
Increase AVG_SHU by ten hours	.77 to .79 percentage point increase
Increase AVG_UND by 1 percent	.86 to .91 percentage point increase

Source: Quester and Marcus, How OPTEMPO, Crew Turnover, and Material Condition affect the Training Readiness of Surface Combatants, p. 17. March 1989.
Note: CASDAYs are defined as the number of days in a 30 day period (1 month) with CAT 3 and CAT 4 CASREPS. The dependent variable for Quester and Marcus's equation.

C. WEAPON SYSTEM ADVANCES

The past twenty years have produced many technical developments for weapon and engineering systems. These developments have greatly improved combat effectiveness and responsiveness. Automation in gun mounts is one example of this technology. However, is the increasing cost of manpower the incentive for the advanced technology and automation? Specifically, was the automated gun designed for manpower savings, or was it designed to provide a tactical advantage in the war fighting arena?

Another development in weapon systems provided combatants with missiles. These missile systems proved to be more tactically beneficial than the automated gun. They provided combatants with longer ranges of offensive and defensive fire power. While missile systems have traditionally not required as many persons to operate as gun

systems, the maintenance required was labor intensive. Specifically, the systems launchers required many hours of preventive maintenance to ensure smooth operation, until the 1980's when vertical launching systems, (VLS), became feasible. The commissioning of the USS Bunker Hill, (CG 52) proved that a ship could be more versatile with VLS and less manpower intensive. VLS would require little if any maintenance. However, because the Bunker Hill was a Ticonderoga class cruiser, she received a similar complement in crew as the other ships in the class. Manpower savings was not the incentive for VLS. Tactical advantage was gained with the capability of over thirty more missiles including the new tomahawk cruise missile.

Radar systems have also advanced over time. However, while the systems have definitely become more capable, they have become more costly to maintain. Maintenance hours is just one facet in these system's increased cost.

Most advanced systems have provided combatants with an introduction into the information technology, (IT) arena. IT is one of the tactical benefits gained by the advanced radar system identified as AEGIS. This system, first utilized by the Ticonderoga class cruisers, provides symbology on large screen displays and operator consoles for quick tactical decision making. The AEGIS display system (ADS), is the cornerstone of IT management for these combatants. Having this automated capability with human interface has allowed a significant reduction in operators and response time. However, this interface has not been fully be utilized for manpower savings. Its main purpose was tactical.

D. ENGINEERING SYSTEM ADVANCES

The most significant reduction in manpower from engineering systems has been derived from gas turbine marine, GTM, engines. By using GTM's to power combatants, manning reductions have been possible. However, was manpower reduction the focus of the implementation? GTMs provides surface combatants with an operational advantage. Specifically, the GTM only requires minutes to align and start provided lube oil supporting systems and fuel oil systems are operating at specific temperatures in accordance with EOSS, engineering operating sequencing systems. This advancement makes the fleet more mobile and responsive. Other advantages include lower fuel consumption and less acoustically detectable operations.

E. PAST POLICY ATTEMPTS TO REDUCE MANNING

Reduced manning is not a new goal. As mentioned, the Navy has benefited from indirect reduced manning in weapon systems and engineering. The Navy on several occasions has attempted to benefit directly from reduced manning. Three of these attempts occurred in the 1970's. Two were in the construction of new platforms, the Spruance class destroyer, DD 963 and the Oliver Hazard Perry guided missile frigate, FFG 7. The third was in a program similar to Smart Ship today, implemented on the test ship USS McCandless, FF 1084, during the period of November 1976 to January 1977, [Ref. 19:p. 19].

In the development of the DD 963 class, roughly 225 crew members were originally assigned. The manning requirements were based on a task analysis of

maintenance and watch standing requirements. However, the Navy quickly realized how minimally armed the warship was, and devised ways to improve its combat power. In addition, the crew had to be increased to meet maintenance requirements and shipboard training. As a result the present compliment is approximately 325-350.

The Oliver Hazard Perry class was designed under the concept entitled high mix, low mix. This strategy envisioned the need for highly capable and high cost cruisers and destroyers to serve in areas of severe enemy threat, while less capable, less costly frigates served in areas of low enemy threat. As a result, the low mix ships received less attention in material condition and maintenance from shore facilities. Crew size was not large enough to complete repairs alone, and combat readiness decreased, [Ref. 20:p. 93].

The ship control function has been viewed by many as an overmanned requirement for decades. Both tradition and decreased training opportunities have continued bridge manning of over 10 members per watch. Therefore, manpower is diverted from other tasks, such as maintenance and administration, in an attempt to keep ship control personnel trained. The integrated bridge system (IBS), a significant part of Smart Ship technology, was evaluated aboard USS McCandless for a period of 3 months. It proved that watchstanding manning requirements could be reduced. However, it was not seen as cost effective by Navy leadership. Specifically, there was a higher priority for weapon and sensor development and acquisition, [Ref. 19:p. 20].

Other technological improvements which had the potential to reduce manpower included a study by Purdue University in the 1960's, funded through the Advanced Research Projects Agency (ARPA). The study's purpose was to evaluate the possibility

of automating several processes aboard destroyer escorts in an effort to reduce manning requirements. The Purdue University study offered a solution which included adding computer technology aboard for the time. However, the proposal was determined not to be cost effective because the reductions in crew members occurred only in the lower paygrades creating a more top heavy Navy, [Ref. 21:pp. 14-15].

III. SMART SHIP

A. INTRODUCTION

Operating cost in the Navy are continuing to increase. As the defense budget continues to shrink from Congressional pressure, the Navy is required to reduce spending and cut overhead. The new era of thinking is to have Navy operate like corporate America, (e.g. to become more efficient and effective).

For years the Navy has been extremely effective, with some efficiency. However, for the Navy to operate effectively requires lots of money. Arguably with increased efficiency will come decreased effectiveness. Congress along with Navy leadership must decide what levels are acceptable.

For the Navy to meet these objectives of efficiency and effectiveness, it must identify and review all fixed and variable cost associated with the budget. One of these costs, manpower, is presently the most vulnerable to being cut. However, past experience shows that fleet manpower reductions have failed not only due to the factors of culture, tradition and policies, but because of decreased mission readiness (e.g. effectiveness).

One of the reasons for MPN's vulnerability is the underlying assumption in the fleet that manpower is free. Specifically, if a body was available, it was used, no matter how impractical, or inefficient the job was. However, that same body could also be part of a major action hours later which could save lives, equipment or the entire ship.

B. THE CATALYST

The Naval Research Advisory Committee submitted a report to Admiral Boorda, Chief of Naval Operations 1994-1996, on possible solutions that could reduce workload and manning requirements aboard surface combatants. The report revealed no specific laws, with the exception of a posted lookout, which required the number of sailors Navy ships must maintain. The panel suggested the Navy shift its focus from using technology as a tactical and operational benefit to using technology as a means to reduce manpower by improving personnel productivity.

USS Yorktown was nominated and approved to be the experimental ship in November 1995. Prior to Yorktown's approval, it was assigned to a new homeport and a battlegroup in the Gulf of Mexico. This battlegroup is specifically designed to deploy for only four to five months in the Caribbean to deter and track drug operations off the coast of South America.

C. SMART SHIP PROJECT OVERVIEW

The Smart Ship Project (SSP) was created to cut through bureaucratic and cultural obstacles in the implementation of innovative new ideas for current and future surface ships in the US Navy. [Ref. 5]. Smart Ship is referred to as the vanguard of cultural revolution in the Navy, challenging corporate thinking on shipboard manning issues. A team for Smart Ship was developed from fleet organizations across the Navy in an attempt to change the way the Navy outfits and mans ships. However, a primary goal besides cost effectiveness was to reduce the shipboard work load. The directives the team received

from Admiral Boorda were to challenge policy, culture, and tradition which contributed to unproductive workload. Boorda also tasked them to incorporate modern and current technology which could minimized human interface and improve productivity.

As part of the new technology, USS Yorktown will receive a fiber optic local area network (LAN), an integrated bridge system, (IBS), a damage control system, (DCS), an integrated condition assessment system, (ICAS) and a standard monitoring and control system, (SMCS). The tactical action officer, TAO, will control all ship functions from CIC. A fully qualified officer of the deck will be stationed on the bridge along with three personnel to ensure safe navigation, [Ref. 6].

By implementing Smart Ship on all available platforms, the MPN savings would be in the billions of dollars over a life cycle of a ship for all affected combatants. However, would this savings be outweighed by the lack of effectiveness that might result? While MPN would gain savings, O&M along with other appropriations may suffer.

D. USS YORKTOWN PROGRESS

After selection USS Yorktown made swift changes to its watch bill without any technological improvements. USS Yorktown adjusted its watch bill underway from 140 men to 77 men, [Ref. 22]. Further watch bill modifications were made by determining these 77 crew members as the "core watch team". If additional personnel were required for special operations such as sea and anchor or underway replenishment, or flight operations, then a support team already designated, the "flex team", would augment the watchstanding core for the evolution. If crew members were not part of these two teams,

they were designated to be "day workers". As an incentive for the day workers to qualify and stand watch, core watch members only stand watch and are not required to perform the daily maintenance and routine duties that most sailors are familiar with.

The damage control and general quarters procedures were also changed. General quarters was eliminated. Condition three watchstanders in the core would fight the ship. If a casualty occurred, then damage control quarters would be called away. While the core maintained the watch, a large flex team of 61 crew members would man repair lockers and CCS, (central control station) to conduct damage and casualty control[4]. All other crew members on Yorktown would report either to the helo hanger or foc'sle on standby. Condition Zebra would be set as needed and directed, [Ref. 23].

Engineering spaces will be unmanned, as first designed in the 1970's. There will be safeguards which include monitors and sensors throughout the plant to ensure safe steaming, and to protect the ship from major leaks and fires. An Engineering Officer of the Watch, (EOOW) along with two other personnel will stand watch in CCS as a backup. Primary control of engineering will however, be in CIC. When all is complete, 5.8 million dollars of technology will be added, with a maximum reduction of 25 percent in crew. This is all in an attempt to reduce the largest input to ship life cycle cost, manpower.

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[4] Currently on other Ticonderoga class cruisers, 125 crew members man repair and casualty control stations at GQ.

E. SMART SHIP TRAINING

Yorktown is equipped with the most modern of training rooms in the Surface Warfare community. This provides an atmosphere for training and an enthusiasm to get away from normal daily routines and to actually train. Future plans are being developed to include video tele-conferencing, (VTC) and video tele-training, (VTT), so as to provide training support when deployed.

A training department is also being established with sole responsibility of administrative records, watch bill scheduling and operational training. The department will be chaired by a senior department head, to ensure proper supervision. These procedures are seen by many SWO's as a vast improvement over the current system,
[Ref. 24].

IV. COST AND BENEFITS OF SMART SHIP

A. INTRODUCTION

Smart Ship does not provide the big dollar savings the Navy requires. Only one half of one percent (e.g. 0.54%) of the total DoN budget per year would be saved if and only if every sailor who was removed from their command was terminated from active service. See Appendix A. This savings does not provide for any increased maintenance cost over the current repair budget. This seems risky and imprudent. The Navy could not significantly benefit from reduced manning on platforms all ready in service. It would be better off to use this technology as a combat effectiveness and quality of life measure.

B. THE COST

Decreased manpower has been shown in chapter II to decrease material condition and mission readiness. Material condition is a cornerstone to readiness, as are so many other factors. When material condition decreases, these other factors also experience decreases, for instance, retention, morale, satisfaction with military life and sailor productivity. These factors all represent some unpredicted cost. With decreased material condition, more ships may experience the inability to operate fully ready and safely, thereby placing an added operational burden on other units.

The Navy will not experience another buildup in the near future, especially in these times of budgetary cuts. Therefore, the number of ships will continue to diminish. Some predictions anticipate 290 active warships by 2000, [Ref. 2:p. 2.]. Less ships means more

underway time, therefore less inport maintenance time. By having less people to conduct maintenance at sea, the Navy will most likely experience further shortfalls in readiness. Technology cannot fully correct this.

C. BENEFITS AND ALTERNATIVES

Smart Ship provides solutions to reduce ship life cycle cost. When fully implemented on all available ships, billions of dollars will be saved over the long run in life cycle cost. But at what cost, and what other alternatives are available? Cannot manpower reductions be taken in less risky environments, like shore billets? As briefed by RADM Loeffler, (MPTA sponsor), and confirmed by LCDR Hoskins at NAVMAC, shore billets have not been reduced as drastically as sea billets, [Ref. 24]. It would seem that the CGs and DDGs as our first-line combatants ought to be the last place to make manpower reductions.

Command and control, C^2, are vital in combat. C^2 technology, which is the cornerstone of Smart Ship, provides better command and control performance. Furthermore, it seems if this technology were utilized to supplement the crew rotation of operation and watch standing, more time could be devoted to material condition, training, professional qualifications, advancement opportunities including educational courses and in-rate training, and free time for personnel just to relax. The indirect savings from enhanced retention, reduced attrition and training cost along with improved material readiness might far outweigh any savings from Smart Ship.

Yes, manpower costs can be reduced in the United States Navy. This can be accomplished with recommendations similar to those of the early 1980's, when the DoN was looking for more personnel. The concept is to use people more efficiently, so there are more people to man ships. The potential savings from crew stability - keeping enlisted and officer manpower in place longer - has yet to be realized. This combined with the benefits discussed in studies conducted by CNA, would greatly enhance today's Navy.

D. ALTERNATIVE MANPOWER REDUCTION METHODS

Also indicated in past studies, CO time onboard along with crew turnover are significant variables in mission readiness. According to a study conducted by the Congressional Budget Office at the time of a 600 ship Navy, if sea tours were lengthened three months and shore tours shortened by three months for only half of the enlisted force, then after three years of implementation 14,500 fewer personnel would be required. [Ref. 8:p. 31]. Applying this same logic today would emphasize the reduction of shore billets, not sea billets. Shore billets have remained relatively constant in size since 1989, [Ref. 24]. If we adjusted for the force size today, using an average ratio of 1 ship per 1000 personnel, (aggregate number includes ship manning and shore manning combined, see Figure 2), as implied in the CBO report of 1983 (600 ships, 600,000 personnel), then Navy manpower could be reduced 62,500 to a total of 362,000 end strength, using 1996 data. This reduction would be primarily focused on shore billets. If the ratio of total ship to total personnel is justified, a $2.5 billion savings could be achieved each year, five times the savings of Smart Ship.

Another alternative is possible. The data in chapter II indicates that cutting the number of ships though controversial, may be better than cutting the number of bodies required to operate them. This is because better material condition and readiness are highly correlated with larger crews, [Ref. 13]. It would seem that if the DoN is going to reduce its fleet to the proposed 346, a number not seen in over 50 years, then those ships ought to be maintained at a very high state of readiness. Ships will no longer be allowed to "just get by". They will be required to perform with infrequent overhauls and inport periods. Poor material readiness will lead to more breakdowns and ships not being able to get underway Adequate manning is the best hope of maintaining readiness. The Navy is likely to have ship strength reduced as an action beyond its control. The most prudent course of action would be to ensure that the ships remaining in service are at peak operational readiness for deployment and combat.

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

This thesis favors Smart Ship experimentation. This is the only way the Navy can excel; by challenging its culture. It also favors exploiting technology to improve labor productivity. It is essential that this new technology be proven sound and reliable. If it is not, then it will not be trusted by the sailors. If it is not trusted, then it will not be used as designed. Examples of this can be seen in the engineering plants of the Spruance and Ticonderoga class ships.

However, if DoN is interested in saving manpower dollars in the MPN budget, Smart Ship is not the best solution. While Smart Ship has the potential of saving 0.54 percent of the total DoN budget, this would risk the readiness of the fleet. It is possible that Smart Ship would be able to adapt to the circumstances of reduced manning in the short term. The risk is in the long run: the possibility of having lesser qualified personnel, higher CASREP rates and lower crew moral leading to lower fleet readiness.

If the product of the peacetime Navy is its ships on station, forward deployed and ready to perform their mission at a moments notice, the current goals of Smart Ship will decrease the quality of the product. I believe the entire Navy is involved in supplying the product, (e.g. ships being ready). If this is true, it is not prudent to risk having a lesser product at a fraction of a percent in savings. If MPN costs need to be reduced, then the entire department responsible for the product must be evaluated (e.g. the Navy). I believe when the Navy does this, they will realize that there is still a lot of "fat" which can be

reduced on shore. It seems logical to reduce the overhead cost of the product first, then to reduce the quality of the product.

Nevertheless, Smart Ship experimentation will help the Navy. This new thinking and technology will aid in the development of the SC 21 and the Arsenal ship. It will also provide operational commands with better ways of using manpower. However, the Navy must be extremely careful in any analysis from the Smart Ship assessment, due to the Hawthorne effect (which showed that good people try to make new ideas, even unsound ones, succeed), the Navy could be easily mislead. To truly evaluate this program would require many years and many crew rotations.

I believe if the Navy wants to excel in readiness, than the current program should be used as a combat effectiveness and quality of life improvement measure. Though this thesis offers no proof, I believe the money saved from having higher retention rates in ships more self sufficient and with crews happier on sea duty will far outweigh the money that could be saved under the current program, and without the risk of decreased readiness.

B. RECOMMENDATIONS

Smart Ship has the potential of saving budgetary dollars, while increasing the potential combat effectiveness and mission readiness of the fleet. However, under the current plan, the costs saved do not outweigh the benefits of a fully manned combatant. By modifying the current program higher readiness could be achieved.

The first action which could be carried out by the Navy is a fleet wide order

instructing all unit commanders to implement the watch bill recommendations invented by the USS Yorktown. The ideas and concepts tested on the USS Yorktown are common sense approaches which allow trust in watchstanders and equipment. These concepts free up personnel which makes them available to maintain and repair equipment, clean and preserve shipboard areas and train and supervise subordinates.

The second step for the Navy would be to install the new Smart Ship technology and information technology aboard all surface combatants. The newer the platform, the more cost effective the procedure would be. In turn, this would directly increase the combat effectiveness and possible mission readiness of each and every combatant over time.

Combat effectiveness would be increased due to the increased command and control gained by centralizing all shipboard control and operating equipment. The Commanding Officer would have steering control, propulsion control along with weapon control in the combat information center, (CIC). All of the systems would have reliable back ups. Specifically, they would be backed up by the way the fleet operates today, with personnel in central control station, (CCS) and on the bridge.

I also recommend that crew turnover be reduced. This would require sea duty to be lengthened. To determine the optimum time aboard and cost effectiveness would require the work of another thesis. However, if quality of life was improved aboard ships, sea duty could be extended without drastic negative effects. A by-product of this recommendation would be increased sea pay to off-set any negative effects of longer sea duty.

Current total Navy manpower could be reduced following the guidelines in the 1983 CBO report on the implantation of a 600 ship Navy to increase the sea to shore ratio by eliminating shore billets. The principle is the same today. Shore commands have not adjusted to the draw down like the sea going, operational commands.

To reduce manpower in the future, while maintaining readiness, new warships must be designed with manpower in mind. This must be done by deciding what missions the Navy will be carrying out and the policies of the United States. The Navy will then be able to construct ships using available technology with a set number of personnel in order to man them. The manning plans for the Arsenal ship illustrate this.

Over the past 100 years ship size has been the primary variable in manning a ship. Specifically the bigger the ship, the more men required. It has also been determined that ship size is important for future upgrades in technology so as to extend ship life. Therefore, ship upgrades and life cycle cost including manpower must play a part in the development of future platforms, like the Arsenal ship and SC 21.

C. RECOMMENDATIONS ON THE ASSESSMENT

Smart Ship will most likely pass any evaluation or assessment conducted by the United States Navy. A successful assessment will not be due to bias on the evaluators' part, but because of a "Hawthorne effect" by the part of the crew. Specifically, all of the attention, new training and equipment will generate enthusiasm and pride within the crew. The pride and high moral of the crew will allow them to pass any evaluation under any circumstances.

Other factors which bias the assessment is the Commanding Officer's power of picking which crew members stay, and which crew members will be left behind at the beginning of the deployment. The Commanding Officer's picks will contribute to a successful experiment due to the trust and confidence felt by the crew in their capabilities. While the CO will be limited to picking only assigned crew members, he would not pick non-performers over "hot runners".

The deployment is another unfortunate factor in the assessment of Smart Ship. Even though deploying to the Caribbean for drug operations might be equal to a deployment in the Mediterranean, it will not be perceived that way by the rest of the fleet. Specifically, the length is shorter, the support is closer and the OPTEMPO slower. Time is what causes malfunction and wear; wear not only in equipment, but in personnel. If this deployment is used for the assessment, it will be regarded with suspicion by the rest of the fleet, regardless of the success.

Convincing the fleet of the wisdom of Smart Ship action needs to be the primary goal of the assessment. Unfortunately, even with favorable cost and benefit figures, the fleet will not be totally convinced that Smart Ship will work. Without the approval of the fleet, using "waterfront standards", Smart Ship will fail.

The surface Navy has always tried to perform at its best, even when dealt low crew moral and decreased material readiness. If the fleet feels betrayed, due to increased workloads, degrading systems from neglect and improper maintenance, then the Navy of the late 1990's may resemble the Navy of the late 1970's. A new "hollow force" maybe in the making.

D. FURTHER STUDY

Further study should be completed on Smart Ship and the USS Yorktown after the deployment. Studies should incorporate earlier work completed at CNA by examining ship readiness using material condition and training reports such as SORTs. This will provide better information on how reduced manning affects readiness.

Further study should also be completed on other alternatives. There are several alternatives the Navy can take, but, it must have an understanding of, the probable cost and benefits before undertaking them. This can only be achieved through cost benefit analysis.

Recalling the quote from Admiral Bradley Fiske, to have a great Navy does not mean keeping as many ships as we can, but in keeping those ships we have, ready to fight at a moments notice, to defend our country's policies.

APPENDIX A: COST SAVINGS OF SMART SHIP

Two approaches can be used to predict the cost savings of Smart Ship. The following information is known:

Total number of ships (combatants) affected=119
Average manning for ships affected = 401
Average number of Enlisted/ship = 376
Average number of Officers/ship = 25
1996 mean annual cost (includes pay, benefits, housing, retirement, etc)
Officers= $75,726
Enlisted= $33,623
1996 Navy End Strength = 424,500
1996 DoN Budget =$79,252.3 million
1996 DoN MPN Budget =$17,021.5 million

Equation 1.
Cost saved= (Personnel eliminated)(wages, training cost, benefits and basic pay)
or
Equation 2.
Cost saved=(percent of force reduced) (MPN budget)

Using equation 1:

Personnel eliminated (PE) = (number of people reduced / ship)(number of ships affected)

PE = 100 people/ship (119 ships) = 11900 personnel in the Navy. However, this does not allow us to know which ones, officer or enlisted?

Therefore:
if average manning = 401 with 25 officers and 376 enlisted then assuming equal reductions across grades yields

94 enlisted and 6 officers = 100 people / ship

Therefore Cost saved using equation 1:

={6 officers ($75,726) + 94 enlisted ($33,623)}119 ships = ***<u>$430,175,242</u> per year***
or $430,175,242 / $79,252,300,000 =<u>.00542</u> or .54% of DoN budget yearly

Using equation 2.

Percent of total force reduce = 11900 personnel / 424,500 = .0280 or <u>2.8%</u>

Therefore cost saved:

*= 2.8% (17,021,500,000)=**<u>$476,602,000</u> per year*** *or* *$476,602,000 is .60% of the DoN Budget.*

There is a .06% or $46,426,758 difference in the two equations. Equation 1 is assumed to be more accurate because individual unit cost are provided. These figures are provided by BUPERS, and are being used by the Smart Ship project. Equation 2 is assumed to be the absolute maximum savings the Smart Ship could justify.

New technology cost are not used in the equation because they are a sunk cost. This cost is $5.8 million / ship for 119 possible combatants.

The savings shown by equation 1 and equation 2 assume that all personnel reduced are eliminated from end strength. The savings is also assumed to be linear. This may not be true. Specifically, the training cost are part of the average annual mean cost for personnel. Therefore, as personnel are reduced throughout the system, the average cost per student trained will increase, assuming training is held constant. Hence, the annual mean cost will increase, resulting in increased marginal savings per year.

The savings also is computed for all 119 combatants being outfitted starting in year 1996. This is logistically impossible, therefore these savings are quite high, compared to actual savings that could be obtained.

Inflation is not accounted for. However, assuming the customary 3% cost of living raise, this would increase the savings marginally for Smart Ship.

The total number of combatants is held at 119 / year. If this number increases, Smart ship would have marginal increases in savings. The same is true if ships are eliminated, and savings would decrease.

APPENDIX B: DEPARTMENT OF THE NAVY, FY 1997 BUDGET SUMMARY BY APPROPRIATION

Department of the Navy
FY 1997 Budget Summary by Appropriation
(In Millions of Dollars)

	FY 1995	FY 1996	FY 1997
Military Personnel, Navy	17,751.8	17,021.5	16,943.0
Military Personnel, Marine Corps	5,735.5	5,843.3	6,102.1
Reserve Personnel, Navy	1,413.6	1,379.4	1,386.3
Reserve Personnel, Marine Corps	351.8	378.2	381.1
Operation and Maintenance, Navy	22,094.6	21,359.0	20,196.2
Operation and Maintenance, Marine Corps	2,139.0	2,420.5	2,203.8
Operation and Maintenance, Navy Reserve	842.3	837.7	843.9
Operation and Maintenance, Marine Reserve	84.8	102.3	99.7
Aircraft Procurement, Navy	4,593.7	4,443.7	5,882.0
Weapons Procurement, Navy	2,377.3	1,765.9	1,400.4
Shipbuilding and Conversion, Navy	6,485.9	6,496.8	4,911.9
Other Procurement, Navy	3,268.2	2,421.4	2,714.2
Procurement, Marine Corps	539.3	638.9	555.5
RDT&E, Navy	8,606.3	8,419.7	7,334.7
Military Construction, Navy	392.6	554.6	525.4
Military Construction, Navy Reserve	22.7	19.1	11.0
Family Housing, Navy and Marine Corps	1,203.6	1,573.4	1,417.9
National Defense Sealift Fund	699.4	1,024.2	963.0
Environmental Restoration, Navy	-	-	302.9
Base Closure and Realignment	1,754.6	2,501.7	1,445.0
Payment to Kaho'olawe	60.7	51.0	25.0

Department of the Navy FY 1997 Budget Summary by Appropriation (In Millions of Dollars)			
TOTAL	**$80,417.7**	**$79,252.3**	**$75,645.0**

Source: Internet, Highlights of the DoN FY 1997 Budget.

APPENDIX C: DEPARTMENT OF THE NAVY, MILITARY PERSONNEL, NAVY

Department of the Navy Military Personnel, Navy (In Millions of Dollars)			
	FY 1995	**FY 1996**	**FY 1997**
Pay and Allowances of Officers	4,341.0	4,303.3	4,299.9
Pay and Allowances of Enlisted	12,048.2	11,439.3	11,132.8
Pay and Allowances of Midshipmen	36.6	35.7	35.3
Subsistence of Enlisted Personnel	538.6	526.0	737.4
Permanent Change of Station Travel	643.7	589.2	593.8
Other Military Personnel Cost	143.7	128.1	143.9
TOTAL: MPN	**$17,751.8**	**$17,021.5**	**$16,943.0**

End Strength, DoN, Navy Personnel			
Officers	58,788	58,400	56,100
Enlisted	371,670	362,100	346,800
Midshipmen/NAVCADS	4,159	4,000	4,000
TOTAL: End Strength	**434,617**	**424,500**	**406,900**

Source: Internet, highlights of DoN FY 1997 budget.

APPENDIX D: MANREQ FORMULATION

$$\text{MANREQ}=\frac{\sum_{I=1}^{9} P_i N_i}{\sum_{I=1}^{9} P_i R_i}$$

Where:

P_i is the average basic pay for the ith paygrade.
N_i is the number of personnel in that paygrade
R_i is the number of M+1 personnel in that paygrade

GLOSSARY

AAW	Anti Air Warfare
ADS	AEGIS Display System
ASROC	Anti Submarine Rocket (long range torpedo)
ASUW	Anti Surface Warfare
ASW	Anti Submarine Warfare
AVF	All Volunteer Force
BUPERS	Bureau of Naval Personnel
BUR	Bottom Up Review
CASREPs	Casualty Reports
CBA	Cost Benefit Analysis
CCS	Central Control Station, Engineering
CG	Cruiser, Guided missile
CIC	Combat Information Center
CNA	Center for Naval Analyses
CNO	Chief of Naval Operations
CO	Commanding Officer
C^2	Command and Control
DCNO	Deputy, Chief of Naval Operations
DCS	Damage Control System
DD	Destroyer
DDG	Destroyer, Guided missile
DIVO	Division Officer
DoD	Department of Defense
DoN	Department of the Navy
EAOS	End of Active Obligated Service
EOOW	Engineering Officer Of the Watch
FF	Frigate
FFG	Frigate, Guided missile
FY	Fiscal Year
GAO	General Accounting Office
GSE	Gas Turbine Technician, Electrical
GSM	Gas Turbine Technician, Mechanical
GTM	Gas Turbine Marine
Harpoon	Anti-ship cruise missile
HSDG	High School Diploma Graduate
IBS	Integrated Bridge System
ICAS	Integrated Condition Assessment System
IT	Information Technology
LAN	Local Area Network
MPN	Manpower Personnel Navy Budget
NAVMAC	Navy Manpower Analysis Center

NRAC	Naval Research Advisory Committee
OOD	Officer Of the Deck
O&M	Operation and Maintenance
PRD	Prospective Rotation Date
RDTE	Research, Development, Test and Evaluation
SC21	Surface Combatant of the 21st century
SMCS	Standard Monitoring and Control System
SM2	Standard Missile variant 2, AAW
SORTS	Status Of Resources and Training System
SSP	Smart Ship Project
SWO	Surface Warfare Officer
TAO	Tactical Action Officer
TLAM	Tomahawk Land Attack Missile
Tomahawk	Long range strike missile
VLA	Vertically Launched ASROC
VLS	Vertical Launching System (MK 41)
VTC	Video Tele-Conferencing
VTT	Video Tele-Training

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